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DEPARTMENT OF THE ARMY
Fort Detrick
Frederick, Maryland

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Patent - Apparatus for the Separation of Solid and Liquid Particles from a Gas-stream with the Aid of Some Radioactive Ionizers

The object of the invention is an apparatus for the electrostatic separation of solid and liquid particles from a continuous current of gas. The gas stream which is to be purified is exposed to radioactive radiation sources for the ionization of the streaming gas molecules, which in turn electrically charge the solid and liquid particles which are carried along by the gas stream. Moreover, the gas flows through a system of electrodes which is combined with an electric source of electromotive source and an electric field is produced which is oriented across the direction of the streaming of the gas streaming and a deflection of the particles, which are carried along and which are charged electrically, likewise transverse to the streaming gas is produced. The deflected particles which are consequently put in motion at the electrodes are separated there and remain adhering. Thus, such a low potential (voltage?) exists in the system of electrodes that with certainty neither a luminous current discharge nor the appearance of sparks occurs.

Electrostatic dust arresters are known in which such a high electric field intensity prevails between the arresting electrodes that an electric luminous current discharge impinger upon the electrodes and therefore an ionization of the gas molecules which are streaming through the separator is produced, and an ionization stream arises between the electrodes which for its part causes the charging of the particles which are carried along by the stream of gas. The charged particles are put in motion then under the effect of the electric field from the electrodes and are separated there. That kind of electric separator, however, has the basic (systematic?) disadvantage that very high electric potentials are necessary and the luminous current discharge leads to the production of ozone and other undesirable gases. On this basis such separators are not suited for the air purification in air conditioning plants and could not be employed because of the danger of explosion with inflammable powder (dust?) mixtures.

Another known apparatus method of electrostatic separation possesses a special chamber for ionization of the gas molecules for the purpose of charging the particles which are carried along by the gas stream and a second chamber for separating them in an electrode system. Ionization of the gas, however, is also produced by an electric luminous current discharge which is produced in the immediate environment of a thin wire electrode. In the short duration, during which the gas stream is subjected to the luminous current discharge, a reduction of the ozone production should be obtained, and the formation of the other unfavorable gases be avoided by the purification of the air current. However, the ozone production is

sufficiently great to exclude the use of such an air purifier in air circulation air conditioning plants without supplies of fresh air. The corrosive gases which are produced also are annoying in many industrial uses of such a separator, and the danger of explosion is in no way decreased by the described construction.

On the other hand, in the separator according to the invention under consideration, the necessary ionization of the gas molecules is not produced by an electric luminous current discharge but by the use of a radioactive radiation of the gas stream. The potential obtained at the electrodes of actual separation system is so small that luminous or spark appearances are absolutely avoided so that also the use in the case of explodable powder or vapor mixtures of the respective gases is allowable. The formation of ozone or other annoying gases is avoided so that the separator according to the invention under consideration can also be employed in air conditioning plants without the disadvantage of purification of the circulating air and without supplies of fresh air.

The ionization of the gas molecules by radioactive sources of radiation is produced, is dependent on the radiation of positive Alpha and negative Beta particles, whereas the Gamma photons which are radiated from many substances are less active. The Alpha as well as the Beta particles produce by impulse many positive gas ions in great numbers, whereas the electrons which become free in the presence of the impulse ionization produce on the other hand, a small quantity of negative gas ions. The gas ions produce for their part, due to the constant heat transfer, a charging of the particles suspended in the gas stream. The kinetic energy of the particles emitted by the radioactive substance is so large that the potentials employed in the system of electrodes do not influence their paths, independent of the polarity of the particles.

In figures 1 to 6 are indicated, for example, designs of separators with a radioactive ionizator.

Figure 1 shows the principle of a separator in a cylindrical type of structure.

Figure 2 exhibits, for example, a form of design for the formation of radioactive sources of radiation.

Figure 3 indicates the construction of the separator in a cylindrical type of structure with flushing, high tension apparatus and automatically controlled valves.

Figure 4 shows a form of design in a box-shaped structure.

Figure 5, for example, shows the type of design of a separator with separate frame shaped ionizators and a plate shaped system of separator-electrode.

Figure 6 shows, for example, the design of a separator with a radioactive counter-current ionizator.

The principle of one separator with a radioactive ionizator is shown in Fig. 1 in a cylindrical structure. In order to purify the gas at rear (1) of solid and fluid particles which are carried along stream through a metal tube (2) in which a metal rod is arranged concentrically in such a way that the metal tube 2 and the metal rod 3 are electrically rotated from each other and from a pair of electrodes which are connected with the voltage source 4. The metal tube 2 supports shortly behind its intake port on the inside a relatively small, ring shaped plating 5 of radioactive material which emits predominately Alpha particles. The Alpha particles which are radiated from the radioactive plate 5 concentrically in the direction of the inner electrode produce the desired strong ionization of the gas molecules which are found at times in the radiated cross-sectional places and instead form predominately positive gas ions. The outer electrode 2 which is opposite the inner electrode 3 and which is negative due to the battery 4, exerts an attractive effect on these positively charged gas ions so that a stream of ions results in the direction of the outer electrode. This stream of ions does not flow only in the cross sectional plane which is radioactively radiated but also reaches the entire cylindrical system of electrodes as far as these are carried along by the gas stream. A stream of ions of this kind across the streaming direction of the gases produces, however, according to experience, a positive charging of the solid and liquid particles which are carried along by the gas stream, practically without regard to their size and diameter. The particles which are thus positively charged undergo, along the entire cylindrical electrode system owing to the negative potential of the outer against the inner electrode, a deviating force across the direction of streaming of the gases and travel to the outer electrode, on whose inner wall they become precipitated and adhere. With suitable amounts of streaming velocity, Alpha-intensity, width of the radioactive plating and length of the system of electrodes, a separation of practically all of the solid and fluid particles which are carried along by the gas stream, results. Thus, the potential at the electrodes and the strength of the electric field in the immediate region of the inner electrode which are obtained are sufficiently small that it is certain that spark and luminous current discharge are in order.

For the desired performance of the radioactive ionization as a means for the electric charging of the solid and liquid particles which are carried along by the gas stream, it is not necessary that an electric field prevail at the same time in the cross sectional plane which is radioactively radiated. On the contrary, without impairment of the effect in the electrode system of Fig. 1, the rod shaped inner electrode can be shortened so much that the gas stream, after its entrance into the outer tube, first of all streams through the cross section plane which is radioactively radiated and enters after that, the field which prevails between the outer and inner

electrodes. In this case the gas molecules become radioactively ionized in the radiated space and produce for their own part, without which an ionization stream is formed, the same electric charging of the solid and fluid particles, which are carried along by the gas stream, by means of the impact on account of the constant heat transfer of the gas ions and the relatively small "free path lengths".

However, since the range of transmission of the Alpha-particles which are especially important for the ionisation is rather limited in a gas and amounts to only a few centimeters, the relationship of the diameter of the metal tube (2) and the inner electrode (3) is so chosen that the open radial distance between the two electrodes is not greater than the maximum range of transmission of the emitted Alpha particles.

The radioactive plating on the inner side of the outer electrode of Fig. 1 which is decidingly important for the function of the separator, is in an exemplary design in Fig. 2 in top view and cross-section, in which design the same kind of radioactive sources of radiation already known for other purposes are used. From a band-shaped metallic lining (1) in the freer portion, the radioactive substance 2 is introduced by means of an electrolytic separation or another means, whereby laterally a non active margin remains exposed. The active section by means of a thin metal foil 3, for example of gold, is uncovered which is plated on is electrolytically introduced and the latter is combined with the metallic lining, so that the radioactive section is closed completely gas tight. The covering foil 3 is made so thin that on the one hand only a small part of the desired Alpha radiation is absorbed, but on the other hand the emergence of the radon gases which arise in the radioactive disintegration is avoided with certainty.

The metal band shown schematically in Fig. 2, with a radioactive filler deposit, is attached in the case of the cylindrical separator according to Fig. 1 thus to the inner wall of the outer electrode so that the active surface is directed with the thin covering foil according to the inner space of the cylindrical electrode system. Thereby no further barrier of the free radiation of the Alpha-particles is place in the way, and at the same time the backward emergence of the radioactive radioactive radiation through the outer electrode is additionaly lessened. "ith The use of an intensive radium preparation a further shielding by means of a lead ring is necessary, which is placed about the outside of the electrode (2).

The equal performance of the radioactive ionizators in the principle arrangement according to Fig. 1 is obtained if the ring-shaped covering (5) of the radioactive substance is not placed on the inside of the outer electrode (2) but on the outside of the inner electrode (3). In the latter case the active side of the covering must naturally be directed outward for the purpose of radioactive radiation of the inner space of the concentric electrode arrangement, and moreover approximately the equal number of gas ions must be produced per unit space in the cross section which is radioactively radiated as in the arrangement of the radioactive lining which is

shown in Fig. 1.

Figure 3 shows an exemplary construction of a separator with a radioactive ionizator in a cylindrical type of apparatus. The air stream to be purified enters at 1 in the apparatus and is fed over the bend of the tube (2) of the electrode systems. This consists of the cylindrical outer electrode(3), which is seen in section, which is electrically insulated with an insulation using (4 and 5) from the construction above it as well as the tube shaped inner electrode (6) which is arranged consecutively. The inside of the bend of the tube (2) bears a ring 7 which includes the radioactive substance and erradiates the predominately Alpha-particles. The gas stream which passes out from the lower end of the electrode system is turned around in a ring shaped housing 8 and leaves the apparatus at(9). The insulated and suspended outer electrode 3 is connected to the negative pole 10 of the high tension source 11 whose positive pole is fastened to the inner electrode 6 and therefore to the housing of the apparatus. The particles which leave the gas stream, which are deposited on the inner sides of the outer electrode in the operation of the separator, form a layer which must be removed from time to time. Moreover, a liquid rinsing is provided for and the inner electrode which is built tube shaped and provided with a perforation 13, through which the rinse fluid enters in the enclosure and is sprayed against the inner side of the outer electrode 3 as soon as the valve(15)is opened by its electric starter(16). The rinse is collecting in the funnel 17 and leaves the apparatus at exit 18, when the valve (19) is opened by its electric starter(30). An operating mechanism (21) comes together with the high tension apparatus which ranks in such a way that in the starter of the inflow valve (5) the source of high tension (11) will be disconnected and at the same time the exist valve will be opened. A time delay in the operating mechanism makes it possible that after the closing of the entrance valve (15) only after the expiration of a previously determined drying time the exit valve (19) likewise automatically closes and the high tension apparatus (11) again will be switched on.

In the exemplary design of the separator in the concentric kind of apparatus in Fig. 3, the radial distance between the outer electrode (3) and the inner electrode (6) is made larger than the maximal transmission range of the Alpha particles which are emitted by the radioactive plating (7) into the gas to be purified, so that the radioactive plating (7) is no longer placed in the bend of the tube but instead on the inner side of the electrode (3) immediately behind the insulation ring (4). Thus, the cross section of the tube which is radioactively radiated is found in the region of the electric field between the electrodes (3) and (6) so that a stream of ions arises which an electric charging of the solid and liquid particles which are carried along in the gas stream, is also produced in such regions of the tube's cross section which would no longer be attained by the radioactive Alpha emission itself.

In the design which is shown again in Fig. 3, the separator with the radioactive ionizator is suited for the purification of small volumes of air or gas, from which the solid and liquid impurities should be separated for which as a rinsing liquid warm water is used. With the parallel

operation of a large number of such separators a larger gas volume could also be purified. Above that the cylindrical separator in this type of construction can however serve with success also for the recovery of valuable substances, which are carried away by the gas or air stream in the form of powder or mist. In these cases at times the passing solvent are used as rinse fluids in order to separate the separator useful material from the undesirable impurities. If necessary for such purposes the apparatus may be partly or completely made from metals or materials which are not chemically attached by the gases to be purified as the substances to be separated.

For the separation of solid and fluid particles from combustible and explodable gases the design of a concentric separator exemplified in Fig. 3 can be used by hermetically insulating the metal electrodes (3) and (6). For this, as an outer electrode (3) a tube of insulating material, for examples, porcelain, glass of an artifical substance, is employed which bears a metallic plating on its outer side which is connected to the terminal (10). Likewise a tube of insulating material provided with perforations is used as an inner electrode which has on its inner side a metallic metal lining which is connected with the terminal (12) and the upper housing. The electric field which arises between the metal lining of both electrode penetrated through the actual insulation sections of the inter space between the inner and outer electrode through which the gas is streaming, so that the separation process is not affected. Probably, however, a direct short circuit between the electrodes is prevented by the accummulation of material or coarse impurities in the gas stream. With suffidently small field strengths in spite of the adequate separator operation, all spark or luminous current appearances are avoided. In the case of this examplary development of the separator with the radioactive ionisator, the latter is also suited for separation of metallic powders.

In concentric separators with a radioactive ionizator for larger gas volumes, a greater number of metal tubes, at times about the equal amount, with a larger diameter are arranged concentrically and insulation from each other and every second tube is connected with the positive pole, the upper tube with the negative pole of a high voltage source. The radioactive ionisator in this case, is placed in one cross-sectional place which lie in front of the entire system of concentric tubes or also it is distributed so that in each single irregular-shaped cell of the separator which are arranged concentrically in each other a cross-sectional plane impervious to the actual entrance of gas is radioactively radiated.

A further exemplary separator design with a radioactive ionizator is given in Fig. 4 in a box shaped type of structure. A metal housing (1) serves as the outer electrode and bears on its inner side close behind the entrance planes a radioactive lining (2) in the form of a small band which emits the predominately Alpha-particles in the direction of the inner electrode (3). This inner electrode (3) consists of . metal plates which are insulated from the outer electrode. Between the outer and inner electrodes

there exists a potential, which produces a sufficiently large field strength in the electrode inner space in order to deflect the charge of particles with an adequate acceleration laterally from the gas stream, but which on the other hand however, with sufficiently certainty still produces no kind of luminous or spark discharge.

In the case of the separator design in the box shaped type of structure shown in Fig. 4, the radioactive lining can be place equally as well on the outer side of the inner electrode provided that the intensity of the radioactive substance which is used is sufficiently large. In this case there is then the advantage that only a slight linear expansion of the radioactive lining is necessary, and at the same time a certain minimal distance of the source of radiation from the housing wall is guaranteed which eventually lightens the necessary shielding measures.

Also in a design like Fig. 4 the radioactive cross-section plane of the electric field in the separator can be arranged, for example by shortening the inner electrode (3), so that the interval of the outer wall of the single box-shaped end of the separator (1) can still be not larger than the doubled maximal transmission range of the Alpha-emission of the lining (2) in the gas which is to be purified. On the other hand the radioactively radiated cross-section plane is placed inside of the electric field of the separator. Thus, this restriction does not hold since in that case an ion stream arises in the cross-section plane in question which produces a charging of the solid and fluid particles which are carried along in the gas stream, also in the region of the cross section plane, which lays outside of the maximal transmission range of the radioactive Alpha particles.

The ionisator which works by means of a radioactive radiation and the electrostatic separator itself, could also be used separately in the box shaped type of apparatus as is shown in principle in an exemplary design in Fig. 5. The gas stream which enters at (1) is conducted through a structure (2) which has on its inner side (3) a radioactive lining with predominately Alpha-emission and possesses such dimensions that in spite of the restricted transmission range of the Alpha particles, the entire inner cross section plane of the structure possesses no unradiated region. The ionisation of the gas molecules in the plane of the structure causes the electric charging of the solid and fluid particles which are carried along by the gas stream, which then enter the electrode system of the electrostatic separator along with the gas stream. The latter consists alternately of metal plates (4) with a positive potential and metal plates (5) with a negative potential. In the case of the flow of the inter space of the plates, the charged particles undergo an attraction directed across the gas streaming by the plates which are oppositely charged in turn, and are moved to these plates and are deposited on the surfaces of the electrodes where they adhere. The electrical field strength in the electrode system of the separator is made only so large that no luminous or spark discharge occurs.

Also with a box-shaped type of construction of the separator with a radioactive ionisator as is shown for example in Fig. 4 and 5, in the case of

use for the separation of solid and fluid particles which are themselves inflammable or are carried along by explodable gases, the metallic surface of all electrodes will be hermetically enclosed with insulating materials.

With the designs of separators with radioactive ionizators which are shown for example in Fig. 1 to 5, at times for simplicity only half the radioactive substance is shown in the form of small streaks or bands, corresponding to the factory process shown in Fig. 2. The manner of operation of the radioactive ionizators is however, in no way hindered if the radioactive substance is not used in the form of that kind of band, but for example are introduced in a width which corresponds directly to the electrolytic or other process of the electrodes in question. It must be entirely assured that the radioactive sections maintain a protective layer which is gas tight but permeable for Alpha-particles in order to avoid the production of radon gas. Also the distribution of the radioactive substance along the entire expanse of the electrode in question is possible.

With the previously known electrostatic separators, in which a separate glow-discharge ionizator is connected to the actual separation cell, the gas stream flows through the active cross-section plane of the ionizator in the very short time of about 20 milliseconds. Thus, the concentration at which ozone is formed in the region of the glow is seldom possible. However, through this short duration in which the gas stream is in the region of the ionizator, on the other hand the desired charging of a possibly larger number of the solid and fluid particles which are carried along by the gas stream will probably be produced only if a strong luminous current discharge and a very high potential is present. With the radioactive ionizator these disadvantages are not present so that a possibly longer duration of the gas stream in the actual region of the ionizator is affected. As this duration is made larger so much the less is the necessary Alpha intensity of the radioactive lining, and respectively so the velocity can be so much the higher.

One exemplary design of a separator with a radioactive ionizator is shown in principle in Fig. 6. The gas stream enters the apparatus at (1), streams through the radioactive ionizator consists of the electrode (2) and the opposite electrode (3) with the radioactive lining (4) and enters the separation chambers which are built from the positive plates (5) and the negative plates (6). The radioactive ionizator is hereby based on the counter-stream principle whereby the potential which exists between the electrodes (2) and (3) on the basis of the ionization produced by the radioactive emission generates an ion stream which proceeds counter to the gas streaming. Through the effect of the counter stream and the long duration of the gas stream in the actual region of the ionizator a really higher grade separation process is obtained.

Claim of the Patent

Apparatus for the electrostatic separation of the solid and fluid particles from a continuous gas stream is thus characterized. The gas stream to be purified is place in a radioactive source of radiation which for its part causes an electric charging of the solid and fluid particles which are carried along by the gas stream. The gas to be purified streams through an electrode system which is connected to a voltage source and an electric field is set up across the stream gas whereby the electrically charged solid and fluid particles undergo a deviation across the streaming gas. The particles travel to the electrodes and are deposited on their surfaces. The field strength in the electrode system is sufficiently small that all glow or spark discharge is avoided.

Subclaims

1. The apparatus is characterized by having the radioactive radiation source on the inner side of the electrode system of the separator and thus the volume penetration by the electric field is at least partially radioactively [illegible]iated.

2. The apparatus is characterized in that the radioactive source of radiation in question, which is used for ionization of the gas molecules which for the purpose electrically charging of the solid and fluid particles carried along by the gas stream, emits predominately Alpha particles.

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